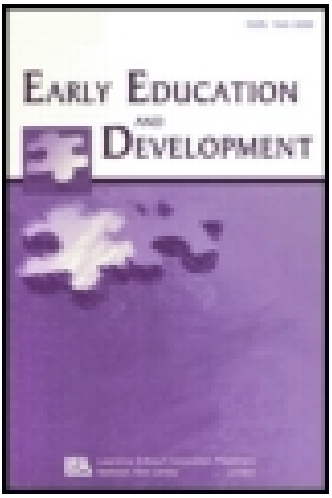

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Educational Gymnastics: The Effectiveness of Montessori Practical Life Activities in Developing Fine Motor Skills in Kindergartners

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Research Findings: A quasi-experiment was undertaken to test the effect of Montessori practical life activities on kindergarten children's fine motor development and hand dominance over an 8-month period. Participants were 50 children age 5 in 4 Montessori schools and 50 students age 5 in a kindergarten program in a high-performing suburban elementary school. Children were pre- and posttested on the Flag Posting Test, an individually administered test of fine motor skill requiring children to place tiny flags mounted on pins into preset pinholes. Students in the Montessori treatment group demonstrated significantly higher accuracy, speed, and consistent use of the dominant hand on the posttest, adjusted for pretest differences and gender. Effect sizes were moderate for accuracy and speed (ds = .53 and .37, respectively) and large for established hand dominance ($\triangle R^2 = .35$). Longitudinal research on the effects of early childhood programs emphasizing the reciprocal interplay of cognitive and physical aspects of activity is recommended. *Practice or Policy:* The findings argue for a balanced approach to early childhood education that maintains the importance of physical activity and fine motor development in conjunction with cognitive skills. Montessori practical life activities involving eye–hand coordination and fine motor skills can be integrated into programs.

Two current strands of research in early childhood development support renewed interest in fine motor development and the relationship between fine motor development, cognitive development, and performance in school. The first strand involves longitudinal studies showing that fine motor skills in kindergarten are predictive of subsequent academic performance in literacy (Brown, 2010; Grissmer, Grimm, Aiyer, Murrah, & Steele, 2010) and math (Grissmer et al., 2010). These studies build on earlier research linking fine motor development to subsequent literacy performance (Reno, 1995) and developmental delays in fine motor development to subsequent educational and social difficulties in school (Cantell, Smyth, & Ahonen,

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1994). The second strand of research, using brain imaging, suggests that most activities that develop or display cognitive skills also involve the use of fine motor skills, and although cognitive and fine motor functions are processed in different parts of the brain, these functions develop in coordination and are activated jointly when performing a wide range of tasks (Adolph & Berger, 2006; Diamond, 2000; Seger, 2006).

Studies have found positive associations between fine motor abilities and cognitive functioning in infants (Miquelote, Santos, Caçola, Montebelo, & Gabbard, 2012) and between handwriting disorders and cognitive functioning in middle childhood (Sandler et al., 1992). These studies are correlational in design, however, and do not take into account change over time. Longitudinal studies provide stronger evidence for the importance of early fine motor development. Grissmer et al. (2010) conducted a secondary analysis of three large longitudinal databases—the Early Childhood Longitudinal Survey–Kindergarten Cohort, the British Birth Cohort Study, and the National Longitudinal Survey of Youth—to determine whether measures of fine motor skills and gross motor skills measured at age 5 (in the case of the Early Childhood Longitudinal Survey–Kindergarten Cohort and the British Birth Cohort Study) or between the ages of 2 and 4 (in the case of the National Longitudinal Survey of Youth) were predictive of later achievement in math and reading when controlling for initial measures of reading readiness and math readiness. Gross motor skills were not predictive of subsequent achievement, but fine motor skills were significantly predictive of achievement in both reading and math in all three data sets. Grissmer et al. discussed these findings in light of evidence of links between motor and cognitive skills from neuroimaging and neuroanatomy research summarized by Diamond (2000) and expanded by subsequent studies.

Historically it was understood that motor activities were associated with the basal ganglia and cerebellum, and that cognitive activities were associated with the prefrontal cortex (National Institute of Neurological Disorders and Stroke, 2014). The basal ganglia, located near the three-dimensional center of the brain, are essential for the initiation and cessation of movement. The cerebellum, located below and behind the basal ganglia, is essential for the regulation and coordination of movement once it has been initiated. The prefrontal cortex is located at the very front of the brain and is the center for executive functions such as planning and decision making. Diamond (2000) brought together studies showing that all three regions are coactivated when doing many cognitive or motor tasks, and subsequent research suggests that motor and cognitive development are inextricably linked. Marsh, Gerber, and Peterson (2008) found that cognitive, fine motor, and attention milestones, mostly driven by the frontal cortices, are dependent on one another, enabling the use of higher order cognitive functions. Many cognitive activities involve control functions initially associated with motor development, and neural links (i.e., synaptic connections among particular neurons regularly activated together) developed to regulate motor learning processes are also used to regulate cognitive learning (Grissmer et al., 2010; Seger, 2006). Adolph (Adolph & Berger, 2006) argued that these links first develop in infancy as infants adapt to changing constraints on physical movement, perceptions of their environment, and growth of their limbs and muscles as they master locomotion and fine motor control. Physical actions and cognitive perception are linked in a developmental loop: "Perception allows actions to be planned prospectively and gears action to the environment. Motor actions complete the perception-action loop by generating information for perceptual systems and bringing the appropriate sensory apparatus to the available information" (Adolph & Berger, 2006, p. 164). These lines of current research support the relationship between physical exploration and manipulation of the physical environment and the development of cognitive schema proposed by Piaget (Piaget, 1954; Sommerville & Woodward, 2005).

Fine motor skills involve eye–hand coordination and control of the small muscles of the body that enable such functions as writing, cutting, grasping small objects, and fastening clothing. The proximal importance of developing fine motor skills is apparent: Weaknesses in this area can delay a child's ability to eat with utensils, write legibly, use a computer, and turn pages in a book and may expose children to ridicule from peers and pose difficulties in meeting the demands of school work (Losse et al., 1991). Reading and writing in particular build directly on the development of fine motor skills (Reno, 1995; Share, Jorm, Maclean, & Matthews, 1984). Studies using functional magnetic resonance imaging have described relationships between fine motor activity and letter recognition in 4- and 5-year-old children (James, 2010; James & Engelhardt, 2012). Brain imaging during letter perception demonstrated activation of regions of the brain known to be associated with reading following practice drawing letters by hand but not after locating letters and typing them with a keypad (James & Engelhardt, 2012).

Despite this evidence, there is little consensus regarding whether instructional activities should be directed explicitly at the development of fine motor skills in the early childhood curriculum and whether proficiency in such skills should be listed as formal outcomes and assessed. Several researchers have pointed out the need for controlled intervention studies to determine the effects of intentional fine motor skill development on fine motor performance and subsequent academic performance (Brown, 2010; Grissmer et al., 2010; Rule & Stewart, 2002).

A distinguishing feature of Montessori programs is the inclusion of *educational gymnastics,* the name given by Maria Montessori (1912) to planned exercises to “develop the co-ordinated movements of the fingers” (p. 144). Maria Montessori saw such activities as part of preparation for *practical life,* such as getting dressed, as well as for academic activities such as writing. The purpose of the present study is to examine the effect of explicit practice based on Montessori educational gymnastics on the fine motor development of young children.

THE PINCER GRIP

One aspect of fine motor movements that has been widely researched is the development of the techniques involved in holding implements when writing and drawing. Rosenbloom and Horton (1971) found that children tend to progress through four predictable stages. They first use a supinate grasp, which is crude and involves the whole hand forming a fist around the writing implement. This grasp is usually used by children who have not yet reached school age. The pronate grasp typically follows and is characterized as a palm-down position in which the fingers curl around the pencil and the index finger points toward the tip. Children usually assume the dynamic tripod by about 7 years of age. In this “mature” position, the thumb, index and middle fingers act as a tripod. They support the writing implement and enable small, highly coordinated finger movements (see Figure 1). The simple tripod in which the correct finger positioning is evident precedes this, but the coordinated finger movements are lacking. Few studies have been conducted on fine motor development beyond early childhood, although

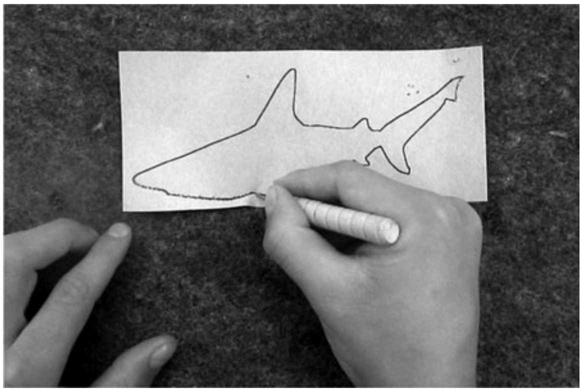

FIGURE 1 Dynamic tripod pincer grip.

Payne and Isaacs (1987) report that the dynamic tripod grasp continues to be refined between the ages of 6 and 14.

HAND DOMINANCE

Hand dominance is an aspect of fine motor development that is directly related to right–left awareness in young children (Kaufman, Zalma, & Kaufman, 1978) and spatial orientation (Bryden & Steenhuis, 1997). Established hand dominance supports efficient and smooth coordination of bilateral fine motor activities and begins to develop in the first year of life (Gesell & Ilg, 1974). It starts with the predominant use of one hand, then the other, then alternating hands, and then both hands together, with a majority of children showing a preference by age 3. Although hand dominance does not become well integrated in some normal children until 8 or 9 years of age (Gesell & Ames, 1947), Kastner-Koller, Deimann, and Bruckner (2007) found that preschool children who used the same hand to perform a task scored higher on a general test of development than children who switched hands to complete tasks.

THE MONTESSORI APPROACH

As the first woman to practice medicine in Italy, Dr. Maria Montessori (1870–1952) spent time working with children in the slums of Rome and quickly became interested in their development. Her scientific observations of this group laid the foundation for a highly organized pedagogy (Lillard, 2005) that has flourished worldwide. Her teaching methods were based on her observations of how children learned, rather than on prevalent beliefs at the time about how children should learn and behave.

Maria Montessori (1912, 1965, 1988, 2004) understood fine motor development to be one aspect of a balanced approach to guided development that included mental, physical, and moral aspects. E. M. Standing (1957) provided a vivid description more than 50 years ago that remains accurate today:

> Visitors to Montessori schools are often surprised to see children engaged in occupations, which sometimes strike them as being out of place in a schoolroom. Thus they may see one child sweeping the floor with a diminutive but real brush, another polishing brasses, a third putting fresh water in flower vases. Other children, armed with dusters, hot water, soap, and scrubbing brushes are carrying out what seems a veritable spring cleaning of the cupboards … no other occupations which could be undertaken by the children at this stage could be more important for their whole development—physical, mental, and moral. (p. 213)

The development of fine motor skills is not clearly enacted as a priority in most public early childhood education. For this reason, the Montessori method, which explicitly emphasizes the development of fine motor skills through the use of so-called practical life activities, provides a de facto laboratory for examining the short-term and long-term effects of explicit instruction and practice in fine motor development. Children in Montessori schools engage with a variety of hands-on materials aimed at helping them to concentrate, develop a sense of order and independence, and hone fine motor skills.

Children in Montessori schools are not initially given a pen or pencil and asked to write the letters of the alphabet; rather, a variety of materials are provided to develop the fine motor coordination of the hand, leading eventually to the use of a pen or pencil. Many of the Montessori practical life activities require using the thumb, index finger, and middle finger, for example, to pick up small objects such as little knobs or small pitchers or to use tongs to transfer shells. Daily practice takes place in these seemingly unrelated activities that are designed to develop the digital dexterity required for the fluidity needed to manipulate a writing instrument later on. A number of these fine motor activities have been used successfully as a means to reach and engage older adults experiencing dementia, arthritis, impairments due to strokes, and problems with vision (Camp, 1999).

RELATED STUDIES AND RESEARCH QUESTIONS

A few studies have examined the fine motor development of children in Montessori environments. Prendergast (1969) found that children from upper-middle-income families in Montessori preschools outperformed children from similar backgrounds attending conventional preschools in eye–hand coordination and visual perception. Similar results were found in a 2-year quasi-experimental study of visual-motor integration and psychomotor skills, including matching and sorting (Stodolsky & Karlson, 1972). A more recent quasi-experimental study (Rule & Stewart, 2002) found that kindergarten students using Montessori practical life activities for 6 months outperformed controls on a test involving picking up and placing copper pennies. The current study sought to extend the findings of Rule and Stewart (2002) through the use of a more exacting and refined task (a timed pin placement test) and attention to hand dominance.

This study used a quasi-experimental design to examine the effect of Montessori practical life activities on fine motor control (both speed and accuracy) and the establishment of hand dominance. It was hypothesized that 5-year-old children who had participated in practical life activities for one academic year would demonstrate greater accuracy, greater speed, and more established hand dominance than a control group of students in a conventional but well-regarded public kindergarten program.

METHOD AND MATERIALS

Participants

The sample for the current study consisted of 100 children in a large city in the western United States. Half ($n = 50$) of the children attended four private Montessori schools and were in mixed-age classrooms of 3 to 6 years. Approximately half the children were in half-day programs and half in full-day programs. The children were all in their third year in a Montessori school, having completed 2 years in preschool and now attending kindergarten. All participated in the traditional Montessori work cycle consisting of an uninterrupted block of work time that included the practical life activities. The families of all Montessori students paid tuition and did not qualify for the federal free or reduced lunch program, and approximately 75% were of European descent. All four participating Montessori kindergarten teachers had undergraduate degrees and were trained and certified as Montessori teachers with a minimum of 2 years of teaching experience.

Control students ($n = 50$) attended a public elementary school serving a relatively affluent neighborhood. The school was selected for comparison because of similarities to the Montessori mission (encouraging a love of learning while teaching independence) and similar background characteristics of students. The ethnic distribution was 74% White, 11% Hispanic, 7% Asian, 4% Black, and 4% more than one race; 7% were eligible for free or reduced lunch. Fifty students were randomly selected from the three kindergarten classrooms in the school, approximately equally divided between the full-day program and half-day program. All kindergarten teachers in the school had undergraduate degrees, were licensed in early childhood education, and had a minimum of 2 years of teaching experience. The instructional approach of the school was identified as exploratory and discovery oriented, with units designed to be thematic. The curriculum included fine motor activities, including cutting with scissors and coloring and drawing with pencils and crayons.

Treatments

In the Montessori classrooms, the shelves containing small items used in daily activities, such as tongs and spoons, were set up with attention to detail, following the principles of the Montessori method. All of the materials were clean and intact, aesthetically pleasing, and inviting. They were placed in a left-to-right progression, moving from simple to complex in level of difficulty. For example, beginning with the pouring exercises, the child was shown very carefully how to pick up the jug on the left, using his or her pincer grip, and pour the beans into the empty jug on the right and then back into the original jug. This was developed further with the child pouring into two equal containers, then pouring into several different-size containers, and then pouring using a funnel. The materials that the child poured were also scaffolded from simple to complex. He or she started with something big and chunky like pasta or shells, progressed to rice or sand, and then eventually progressed to water. Once the child mastered this activity, that child was given opportunities to pour water or juice for the other students during snack or lunchtime. The child's skill and confidence were gradually built up through this scaffolding.

Similarly, the child was shown how to transfer objects using a spoon, a pair of tongs (see Figure 2), and tweezers. Later, as the finger muscles strengthened, he or she was shown how to use clothes pegs, lace cards, sew buttons, polish silver or brass, use the dressing frames that teach the children how to dress and undress themselves, and so forth. All of these materials helped develop the child's eye–hand coordination, pincer grip, left-to-right directionality, concentration, independence, sense of order, self-esteem, and confidence. For example, a child working with the tweezers not only learned how to manipulate the implement with his or her pincer grip and pick up the objects on the tray but also learned to sort and classify the sea animals into fish, turtles, and sea horses. This required the child to concentrate and coordinate his or her movements and in turn built the child's self-esteem and confidence.

The teacher gave demonstrations on how to use the materials, and then the children were free to select their own activities during the 3-hr morning work cycle. The teacher would always have the child sit on her nondominant side when she gave a presentation, follow the left-to-right directionality in the presentation of the materials, give the lesson in silence, and allow the child to practice with the materials on his or her own. Equipment was added and removed each week, thereby keeping it fresh and engaging without overwhelming the children or the classroom environment with too many choices (Lillard, 2005).

In each classroom there was a daily 3-hr work period during which children could choose among six types of activity, including practical life activities. Occasional classroom visits by the researchers confirmed the general adherence to practical life activities, but formal observations were not conducted and the duration of children's participation in fine motor activities was not measured.

Descriptions of fine motor activities in the control classrooms were obtained through structured interviews with the kindergarten teachers but were not confirmed by observation. The traditional kindergarten curriculum was followed, with no use of additional or supplemental materials. Activities included independent reading; science exploration; math; and fine motor activities such as coloring, writing, and creative play with blocks and puzzles. The school used Everyday Math (www.everydaymath.com), involving interactive games, manipulatives,

FIGURE 2 Tongs in practical life activities.

and real-life problem solving, for 20 min daily. Handwriting Without Tears (www.hwtears.com) was used to teach correct pencil grip and handwriting skills. That curriculum is based on a developmental approach, presenting letters grouped by the difficulty of drawing them and emphasizing the use of simple vertical lines (Case-Smith, 2002). Each child participated in this program daily for 20 min. Control group children also had self-selection time (20 min daily) at workstations involving puzzles, word building, sentence structure, blocks, and/or science experiments. These concrete activities encouraged the development of hand–eye coordination, concentration, and independence, but no formal presentations were given to the children on how to use the materials. The use was not as specific as in the Montessori classrooms, but the teachers did ensure that the materials were not misused and that children rotated the materials, giving all a chance to use them. Teachers observed the children during self-selection time and offered help as needed. Children in full-day kindergarten also participated in Enrichment Class, in which they chose among play areas that included a housekeeping corner, blocks, a dress-up area, arts and crafts, science, and computers.

Measures

Dependent measures were three aspects of fine motor control assessed by the Flag Posting Test: accuracy, speed, and established hand dominance. The Flag Posting Test is an individually administered measure of fine motor control yielding scores for accuracy, speed, and hand dominance. The test involves an apparatus (see Figure 3) consisting of a solid hardwood tray covered with clay in which there are 12 pinholes. There are 12 paper flags mounted on pins, six to the left of the tray and six to the right, giving an exact correspondence of holes to flags. The test administrator demonstrates to the child how to pick up a flag with a pincer grip and place it in one of the holes in the tray. The administrator then says, “You may begin,” and starts a stopwatch to record to the nearest second the amount of *time* the child takes to complete the activity (an inverse indicator of *speed,* the construct of interest). Hand dominance is scored by noting which hand the child uses to pick up the flag and place it in a hole. To receive a score of 1 (*established dominance*), the child must consistently use the same hand to place all 12 flags. While the child is doing the work, the tester also notes how the child carries the flag (e.g., with the pincer grip or the use of all of the fingers). When the child has completed the work, the tester counts and records the pin points on the clay (*errors,* an inverse indicator of *accuracy,* the construct of interest) reflecting how many attempts it took the child to put each flag into the hole. Interrater reliability based on score agreement between the first author and third author was calculated using a sample of 12 children ages 3 to 5 external to the study. Agreement with respect to speed

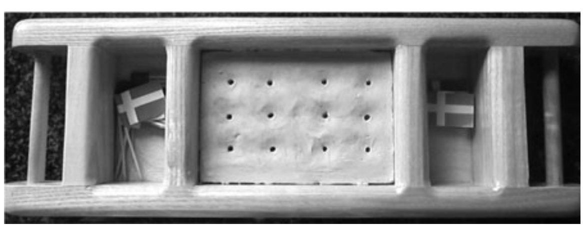

FIGURE 3 Apparatus for the Flag Posting Test.

and accuracy, expressed as Pearson correlation coefficients, was $r = .995$, 95% confidence interval (CI) [.90, 1.00]; and $r = .884$, 95% CI [.65, .94], respectively. Agreement regarding hand dominance, expressed as Cohen's kappa, was $\kappa = .847$, 95% CI [.562, 1.000]. The high estimates of interrater reliability were consistent with indicators of performance that are directly observable and unambiguous.

Procedures

Data collection. All children were pretested the last week of August (approximately 1 week after school started) and posttested during the first week of April (8 months into the school year). A single trained test administrator conducted the test administration. The children were individually tested in a separate room that was attached to their classroom. Care was taken to ensure that the children never felt under pressure and did not feel that they were being tested. If a child was not well, or became tired or uncooperative, testing was terminated and resumed at another session.

Analysis. The *t* test for independent samples was used to test for differences on the pretest means. Analysis of covariance (ANCOVA) was then used to test the dependent variables accuracy and time for main effects for group and sex and Sex × Group interaction, using pretest as a covariate. Hierarchical logistic regression was used to test differences in the dichotomous dependent variable hand dominance associated with gender and the dominance pretest (Level 1) and treatment group (Level 2).

RESULTS

Hypothesis 1: Accuracy

Assumptions for the ANCOVA were checked. The assumptions of independence of observations, a linear relationship between the covariates and the dependent variable, and homogeneity of regression slopes were met. The assumption of a normal distribution of the dependent variable was violated, but ANCOVA is robust with respect to violations of normality of distributions when group sizes are equal (Levy, 1980). The assumption of homogeneity of variances was also violated, but because the cell sizes were similar or identical (Leech, Barrett, & Morgan, 2008), this violation was not a concern.

Independent *t* tests were used to determine whether the control and treatment groups differed with respect to fine motor accuracy and speed before the treatment began. There were no statistically significant initial differences between the control group and the treatment group for accuracy or time: accuracy, $t(98) = -0.506$, $p = .61$, $d = -.07$; time, $t(98) = -0.584$, $p = .56$, $d = -.05$.

At the conclusion of the treatment, ANCOVA was used to test the main effect for treatment and gender with respect to accuracy after controlling for differences in preaccuracy. There was a significant main effect for treatment, $F(1, 95) = 14.90$, $p < .001$, partial $\eta^2 = .14$, $d = -.53$, a moderate effect size. There was no interaction between treatment and gender, indicating that the effect was consistent for both males and females, $F(1, 95) = 1.00$, $p = .321$, partial $\eta^2 = .01$. Table 1 shows the means for both groups before and after, controlling for pretest differences. Note that accuracy was measured through an inverse indicator (errors); therefore, a lower mean indicates

TABLE 1
Fine Motor Outcomes for the Treatment and Control Groups

Variable	*Treatment group* (n = *50*)			*Control group* (n = *50*)		
	M	SD	*Adjusted* M	M	SD	*Adjusted* M
Errors pre	15.24	6.41		14.60	6.24	
Errors post	8.14	4.58	7.98	12.00	7.64	12.13
Time pre	90.58	37.14		86.64	29.93	
Time post	65.64	29.93	64.94	73.76	21.85	74.61

greater fine motor accuracy. Results show a moderate and statistically significant effect for the Montessori treatment condition after adjusting for preaccuracy.

Hypothesis 2: Speed

ANCOVA was used to assess the main effect for treatment on speed as indicated by the inverse variable time required to complete the flag posting task. ANCOVA assumptions were examined. As with accuracy, the assumptions of independence of observations, a linear relationship between the covariates and the dependent variable, and homogeneity of regression slopes were met, but the assumptions of a normal distribution of the dependent variable and homogeneity of variances were violated. The fact of equal group sizes mitigated these problems. The main effect for treatment was significant, $F(1, 95) = 9.19$, $p = .003$, partial $\eta^2 = .36$, $d = .37$. There was no interaction between gender and treatment, indicating that the treatment was effective for both males and females, $F(1, 95) = 0.011$, $p = .917$. Table 1 shows the means for both groups before and after controlling for pretreatment differences. As with the accuracy assessment, a lower mean on this test is desirable, as it reflects faster performance and therefore better fine motor fluency.

Hypothesis 3: Established Hand Dominance

The variable of established hand dominance was dichotomous, coded 0 (no clearly established hand preference) or 1 (clear hand preference). Hierarchical logistic regression was conducted to assess whether the treatment condition was a significant predictor of established hand

TABLE 2
Hierarchical Logistic Regression Predicting Established Hand Dominance From Gender, Pre–Hand Dominance, and Treatment

Predictor	ΔR^2	B	SE	*Odds ratio*
Step 1	.121			
Gender		0.46	.43	1.59
Pre–hand dominance		1.20*	.48	3.33
Step 2	.351			
Gender		0.541	.53	1.72
Pre–hand dominance		2.10**	.64	8.19
Treatment		2.93***	.60	2.52

Note. R^2 refers to Nagelkerke R^2.
*$p < .05$. **$p < .01$. ***$p < .001$.

dominance after controlling first for gender and pretest. In Step 1, gender and pre–hand dominance were entered as predictors. The omnibus test for Step 1 was significant, $\chi^2 = 9.46$, $df = 2$, N = 100, $p < .001$. Pre–hand dominance was a significant predictor ($b = 1.20$, $p = .013$); gender was not ($b = 0.46$, $p = .283$). In the second step, treatment was added to determine whether it accounted for additional variance in the posttest of established hand dominance. Treatment was a significant predictor ($b = -2.93$, $p < .001$) and accounted for an additional 35% of the variance, a large effect size (see Table 2).

DISCUSSION

Results and Limitations

The results from this small-scale study indicate that the Montessori practical life activities had a significant effect on improving the fine motor skills of kindergartners. Students in the treatment group outperformed controls on all three dependent variables of accuracy, speed, and established hand dominance in a flag posting task requiring precise use of the pincer grip. The results were consistent with the small number of previous studies of the effects of Montessori practical life activities on fine motor development but involved a more advanced level of fine motor control and hand–eye coordination than was true in previous studies (Prendergast, 1969; Rule & Stewart, 2002; Stodolsky & Karlson, 1972). Although the study involved a small sample, internal validity is supported by the similarity of the treatment and control groups with respect to demographic characteristics, by the absence of significant pretest differences, and by the use of a pretest as a covariate. Nonetheless, as a quasi-experiment without random assignment of students to treatment groups, it is weaker than a true experiment would have been as a test of a causal relationship.

Another limitation of the study is the lack of data on how much time children spent in practical life activities or the precise nature of the fine motor activities engaged in by control students. Future research should involve classroom observations to document more precisely the differences between Montessori and control approaches with respect to fine motor activities, time spent with them, and variation across children.

Evidence that the Montessori practical life activities are associated with moderate to large effects on fine motor development in comparison with a highly regarded kindergarten program is noteworthy. Greater attention to the development of fine motor skills has been supported recently by a bodies of evidence from (a) large-scale longitudinal studies demonstrating that fine motor development in kindergarten is associated with subsequent performance in reading and writing and (b) brain imaging and neuroanatomy showing that regions in the basal cortex and cerebellum (associated with motor activity) are coactivated with regions in the prefrontal cortex in the context of many cognitive tasks. These bodies of evidence are consistent with a theory of development posing a reciprocal relationship between motor development and cognitive development. Infants confront a series of complex problems in adapting their motions to a changing environment, and over time these adaptations are mediated by internal neural representations of the body in the external environment (Ito, 2005). The regions of the brain involved initially in the motor action may continue to be activated years later as a representation of the motor component when the activity seems to be entirely cognitive.

Restriction of the sample to mainly children from middle-class White families is a significant limitation with respect to the generalizability of the findings to more diverse populations. And although the study drew on research linking fine motor development to cognitive development and academic outcomes, the lack of short-term or long-term indicators of cognitive functioning in this study prevents the drawing of direct, empirically based conclusions about the cognitive and academic benefits of improved pincer grip and fine motor coordination associated with practical life activities. We hypothesize that such a relationship exists and recommend that controlled intervention studies be undertaken to test the hypothesis.

Implications and Conclusions

The findings of this study, in the context of the body of research on the relationship between motor development and cognitive development, argue for a balanced approach to early childhood education that maintains the importance of physical activity and fine motor development in conjunction with cognitive skills. A distinguishing feature of Montessori education is its explicit valuing of balance among physical, cognitive, and moral elements of activity. The importance given to practical life activities in Montessori education is a testimonial to the value of this balance and the endurance of activities that may strike outside observers as quaint or old fashioned. The body of published research on the effects of the Montessori approach is very small, and almost no empirical studies have been completed in the past 10 years. One implication of the present study is that Montessori programs are a potential site for research on the long-term implications of prolonged attention to motor development and on the relationship between fine motor and cognitive development.

Another implication is that public early childhood programs might benefit from incorporating elements of Montessori practical life activities into their curriculum and routines. In addition to their relationship to cognitive tasks, the activities used within Montessori to develop fine motor skills have inherent appeal to most children. For example, a peripheral finding of the present study was that the flag posting material was very popular with the children both in the Montessori programs and in the traditional kindergartens. According to the field notes of the test administrator, children liked to identify the flags and put them in a pattern, and children made comments such as “I love this work,” “These flags are so cute!” “It is so hard for me to get them in the holes,” and “This is our flag.” Similarly, Montessori pouring equipment has the appeal of providing access to adult activity at a child's scale. The use of the materials, always within a context of choice and voluntary engagement, is aimed at developing a positive work ethic and habits of responsibility in addition to increased skill and dexterity.

Fine motor skills do not develop quickly or automatically. They require patience, understanding, time, and practice. Encouraging children to work with their fingers and hands will strengthen the muscles in their fingers and make difficult tasks such as buttoning, writing, and tying shoelaces easier and less stressful. This in turn can contribute to success in school and at home and can lead children to feel good about themselves.

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